**In-Vehicle Driver Distractions: Characteristics Underlying Drivers' Risk Perceptions**

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## Abstract

Driver distraction continues to receive considerable research interest but the drivers' perspective is less well documented. The current research focussed on identifying features that are salient to drivers in their risk perception judgements for 19 in-vehicle distractions. Both technological (e.g. mobile phones) and non technological (e.g. eating) distractions were considered. Analysis identified that males and females were rating 7 of the 19 distractions differently. The current paper presents the data for the female participants (n = 84). Multidimensional scaling analysis identified three main dimensions contributing to female drivers' risk perception judgements. Qualitative characteristics such as the level of exposure to a distraction were identified as significant contributors to drivers' risk perception as well as features inherent in the distractions such as distractions being related to communication. This exploratory work contributes to better understanding female drivers' perceptions of risk associated with in-vehicle distractions. Understanding the drivers' perspective can help guide the development of road safety messages and ultimately improve the impact of such messages.

## Keywords

In-vehicle distraction, risk perception, multidimensional scaling

## Introduction

Driver distraction is consistently demonstrated to be a leading cause of traffic crashes worldwide. This is a pattern reflected in Australia with over 30% of drivers who attended a hospital in Perth, Western Australia, identifying at least one distracting activity at the time of their crash [1]. There are a large number of in-vehicle distractions that have been identified as possible driver distractions in the literature, identified from both questionnaire based studies and lab based and simulated driving experiments.

Simulated driving studies have identified significant negative effects on driving performance as a result of engaging in song searching activities on MP3 players while driving [2, 3], and some detrimental effects of interacting with route guidance systems [4]. In contrast, some research has found no such negative impact from listening to audio material from rear seat audiovisual entertainment [5].

In a study ranking the prevalence of different distracting activities, adjusting in-vehicle equipment was the second most common distraction and included activities such as adjusting climate controls and in-vehicle stereos [1]. It was found that tuning a radio while driving did significantly impact driving performance and the authors suggested that performance continues to decrease the longer the driver takes to tune the radio [6].

Research comparing radio adjustments with dialling a handheld mobile found that the phone task resulted in higher distraction levels [7]. The use of mobile phones can lead to different types of distractions because of their multi functionality (e.g. used as a phone or to text) as well as the introduction of hands free kits rather than hand holding mobile phones. Many studies support the idea that both hand held mobile phone use [8] and hands free use [9] are a distraction to drivers. Results show that conversations on mobile phones can significantly degrade driver sensitivity to perspective information about upcoming events and awareness of the road environment [9] and artificially constrict the drivers peripheral awareness [8]. From the driver perspective results looking at differences between those who use and do not use a mobile phone are noteworthy. Non-users were more likely to rate the use of phones while driving as a dangerous distraction compared to phone users. Further, the mobile phone users displayed illusory beliefs about their own skills by suggesting that they use them in a safer manner than other drivers [10]. Finally, reading or writing a text message has also been found to impair driving performance and is illustrated by increased reaction times causing drivers to slow to compensate for the texting activity, and reducing awareness of the outside environment [11, 12]. Evidence suggests that a substantial proportion of drivers, especially drivers aged 18-30 years, admit to texting while driving [13].

Another form of communication relevant to driving is chatting with a passenger. Language comprehension, when performed concurrently with driving, draws mental resources away from the driving task resulting in deterioration in driving performance [14]. It is suggested that there is actually little difference between talking on the phone and talking to a passenger while driving [15]. However, other researchers believe that communicating with a passenger is less distracting than mobile phone use [1, 16], partly because passengers can moderate their interaction with the driver if necessary. The driver's viewpoint on passengers was assessed as part of a survey of Australian drivers finding that 70% of respondents felt that talking with a passenger was not a distracting activity [13].

Observation work that coded distracting activities while driving found other activities such as grooming, reaching or leaning for an object, reading and writing were relatively common but declined to less than half the participants if observations were restricted to moving vehicles only. Although less common these distractions are included in Stutts et al.'s [17] taxonomy of distractions in everyday driving. Eating and drinking (and the preparation to eat or drink) was also identified as a significant contributor to driver distraction coming top of the list after conversing with passengers. However, it is again a risk that is perceived, by drivers, to be lower than other in-vehicle distractions [18, 19].

There is limited research evidence that suggests how drivers perceive the risks from various distractions. For example, White et al. [18] found that both the use of hands free mobile phones and eating and drinking while driving are perceived as a low risk activity by drivers. Communication with passengers is also considered to be relatively low risk by drivers [13]. Research conducted by Patel et al. [19] included nine in-vehicle distractions in a set of fourteen driver distractions aiming to identify factors that influence drivers' subjective ranking of the distractions. The current study aimed to investigate a larger number of in-vehicle distractions, relevant to as many drivers as possible (and thus avoided distractions such as smoking), to identify if the same qualitative characteristics (i.e. knowledge and familiarity) contribute to drivers' perceptions of risk for a broad range of in-vehicle distractions and to establish if any additional factors could be identified.

The technique used to investigate factors that contribute to risk perceptions is taken from the risk literature that employs the psychometric paradigm [20]. The psychometric paradigm (using Multidimensional Scaling and regression techniques) has been successfully applied to examining the underlying dimensions that influence perceptions of a large variety of hazards among a broad range of demographic groups. Multidimensional Scaling (MDS) is used to construct a 'mental map' that reveals the underlying relationships between the hazards in a graphical display. For instance, Slovic [20] applied the technique to investigating hazard perceptions for a range of environmental hazards, while other researchers have applied it to a more homogeneous set of hazards (e.g., those related to nanotechnology [21]). Qualitative characteristics that are identified from research applying the technique often include the dread from a hazard, the fairness of the outcome and the unknown/familiar nature of the hazard.

The present study examined Australian drivers' risk perceptions of nineteen in-vehicle driver distractions, chosen to represent commonly encountered distractions. The research applied techniques, demonstrated to yield useful results in previous risk perception research, to identify qualitative characteristics that may underpin drivers' risk perceptions for a number of distracting activities. In addition it was of interest to see if the 'perceptual map' identified any features inherent in the distractions that drivers may use to make risk judgements. Such information has important implications for improving the impact of road safety messages because it could aid the tailoring of materials to focus on features of a hazard that are salient to the driver, the receiver of the message.

## Method

### *Participants*

133 participants volunteered to complete an online survey advertised using the Queensland University of Technology *classifieds* list. Classifieds is an electronic facility co-ordinating the buying and selling of goods and services amongst its members, comprising academic staff, professional staff, non-professional staff and students. A total of 105 data sets were retained and included in the analysis (28 cases removed because more than 5% of responses were missing). 95% of the participants had a Full driving licence, 3% a Provisional licence and 2% a Learner licence.

### *Materials and Procedure*

Respondents were required to complete an on-line self-administered questionnaire based on nineteen in-vehicle driver distractions. Distractions were carefully selected to include only those that all participants were likely to encounter thus excluding distractions such as smoking. The distractions investigated were: device (using a device brought into the car, e.g. palm computer); listen GPS (listening to route guidance from a satellite navigation system); enter GPS (entering information into a satellite navigation system); adjusting climate controls; using a hand held mobile phone; using a hands free mobile phone; reading or writing a text message; eating or drinking; looking at a map or book; grooming (e.g. looking in the mirror, combing hair etc.); tuning the radio/searching a CD; listening to music; adjusting your seatbelt; communicating with a passenger; reading (e.g. mail/newspaper); reaching or leaning for an object; listening to a radio talk show; passenger in-vehicle entertainment; writing (e.g. in a notebook). To aid interpretation, examples were given for some distractions such as the item: "grooming (e.g. adjusting hair/make-up)". Participants rated the nineteen distractions on a 10-point risk scale (from 1 = very low risk to 10 = very high risk). Then all distractions were rated on a further 7 qualitative characteristic scales: familiarity, knowledge, voluntary or imposed, exposure, probability of a crash, mental concentration, and control. These were selected on the basis of frequent identification in previous studies investigating different hazard areas and their relevance to driving [20, 22].

## Results

Multivariate analysis of variance (MANOVA), followed up using discriminant analysis, identified that male and female respondents were providing significantly different ratings on the risk perception scale (a small number of males were included for comparison purposes). Due to the differences data from the male and female respondents required separate analyses to be undertaken and there were insufficient numbers of male respondents (n = 21) for direct comparison using the same techniques. The current paper presents the data from the female respondents (n = 84, age range 18-64 years, 18-24yrs = 18%; 25-39yrs = 58%; 40-49yrs = 17%; 50-64yrs = 7%)) and a discussion of young male driver perceptions of in-vehicle distractions from a separate study can be obtained from the author.

### *Risk and Exposure ratings*

Typically respondents made good use of the full range of the 10 point scales suggesting that both exposure to and perceptions of the different distractions were quite varied. Female participants' mean risk ratings for all 19 distractions are illustrated in Table 1. The most risky distractions were rated as reading, writing, texting, and using a handheld mobile phone. In contrast, those distractions rated as low risk were communicating with a passenger, listening to a radio talk show, and listening to music.

Table 1: Risk Perceptions for the nineteen distractions (means and standard deviations)

| Distraction | Mean | *SD* |
|---|---|---|
| reading | 8.94 | 1.67 |
| writing | 8.86 | 1.70 |
| text message | 8.61 | 1.73 |
| hand held mobile | 8.61 | 1.90 |
| looking at a map | 8.01 | 2.13 |
| reaching, leaning for object | 7.99 | 1.85 |
| entering info into sat nav | 7.64 | 2.34 |
| device brought into car (e.g. palm pilot) | 7.45 | 2.53 |
| grooming | 7.02 | 2.60 |
| tune radio/search CD | 5.40 | 2.29 |
| passenger entertainment (e.g. TV/DVD) | 5.40 | 2.51 |
| eating or drinking | 5.21 | 2.21 |
| hands free mobile | 5.05 | 2.17 |
| adjust climate controls | 4.43 | 2.26 |
| listening to sat nav | 4.40 | 2.27 |
| adjusting seat belt | 4.17 | 2.16 |
| communicating with a passenger | 3.15 | 1.70 |
| listening to radio talk show | 2.96 | 1.71 |
| listening to music | 2.48 | 1.77 |

The level of exposure reported for each distraction is also important for establishing the level of risk associated with a given distraction (Table 2). For this female sample, exposure to gadgets was low with both passenger entertainment and using GPS systems receiving a mean score below 3 and reading and writing were the distractions with the lowest exposure ratings. Listening to music was given the highest exposure rating with an average of 9.15 which was far above the next highest ranking distraction; communicating with a passenger. There was also a strong negative correlation between the risk ratings and the ratings for exposure $r^2 = -.75$, $p < .001$.

Table 2: Exposure scores for the 19 distractions (n = 84, means and standard deviations)

| Distraction | Mean | *SD* |
|---|---|---|
| listening to music | 9.15 | 1.57 |
| communicating with a passenger | 6.75 | 2.15 |
| adjust climate controls | 6.63 | 2.87 |
| tune radio/search CD | 6.50 | 2.98 |
| listening to radio talk show | 6.27 | 3.30 |
| eating or drinking | 4.81 | 2.38 |
| reaching, leaning for object | 4.67 | 2.45 |
| adjusting seat belt | 4.55 | 2.76 |
| text message | 3.75 | 2.58 |
| hand held mobile | 3.62 | 2.67 |
| looking at a map | 3.55 | 2.21 |
| hands free mobile | 3.55 | 3.09 |
| grooming | 3.54 | 2.58 |
| listening to sat nav | 3.02 | 2.87 |
| passenger entertainment (e.g. TV/DVD) | 2.86 | 2.51 |
| entering info into sat nav | 2.08 | 2.09 |
| device brought into car (e.g. palm pilot) | 1.54 | 1.24 |
| writing | 1.44 | 0.95 |
| reading | 1.42 | 0.95 |

*Multidimensional Scaling (MDS)*

A proximity matrix was created (using the Euclidean distance measure) from the aggregated risk perception scores for each distraction. This was analysed using MDS (ALSCAL method) to identify the most likely number of salient dimensions used by respondents to form their risk perception judgements. The goodness of fit using s stress scores improved little beyond 3 dimensions (2D to 3D = .008 improvement, 3D to 4D = < .001 improvement) and together with the added difficulty with interpreting models with more than 3 dimensions [23] a 3 dimensional solution was selected as the most appropriate fit with $R^2$ = .99, stress = .05. The solution produces a visual map that places all the distractions according to their similarity in terms of perceived risk in 3 dimensional space. For ease of interpretation the resulting maps are illustrated using two dimensional representations in Figures 1 and 2.

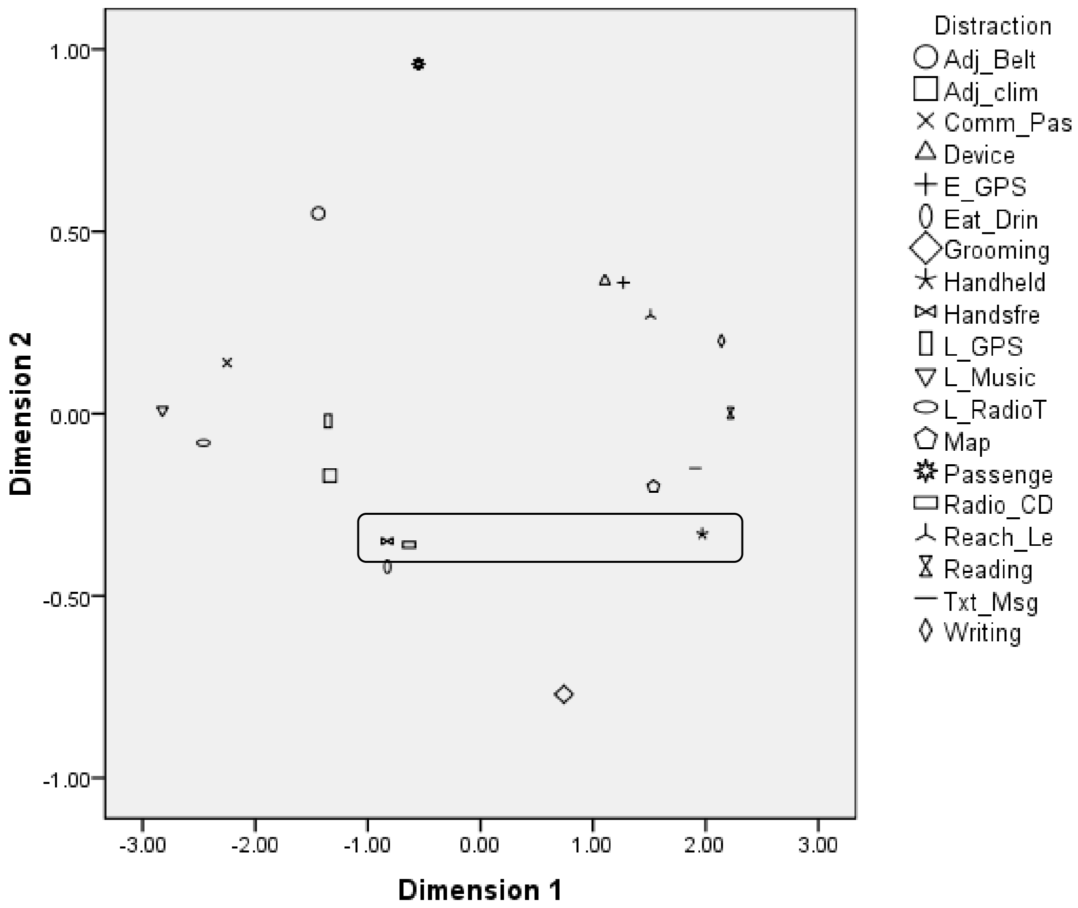


Figure 1: perceptions of risk for each driver distraction represented on dimension 1 & dimension 2

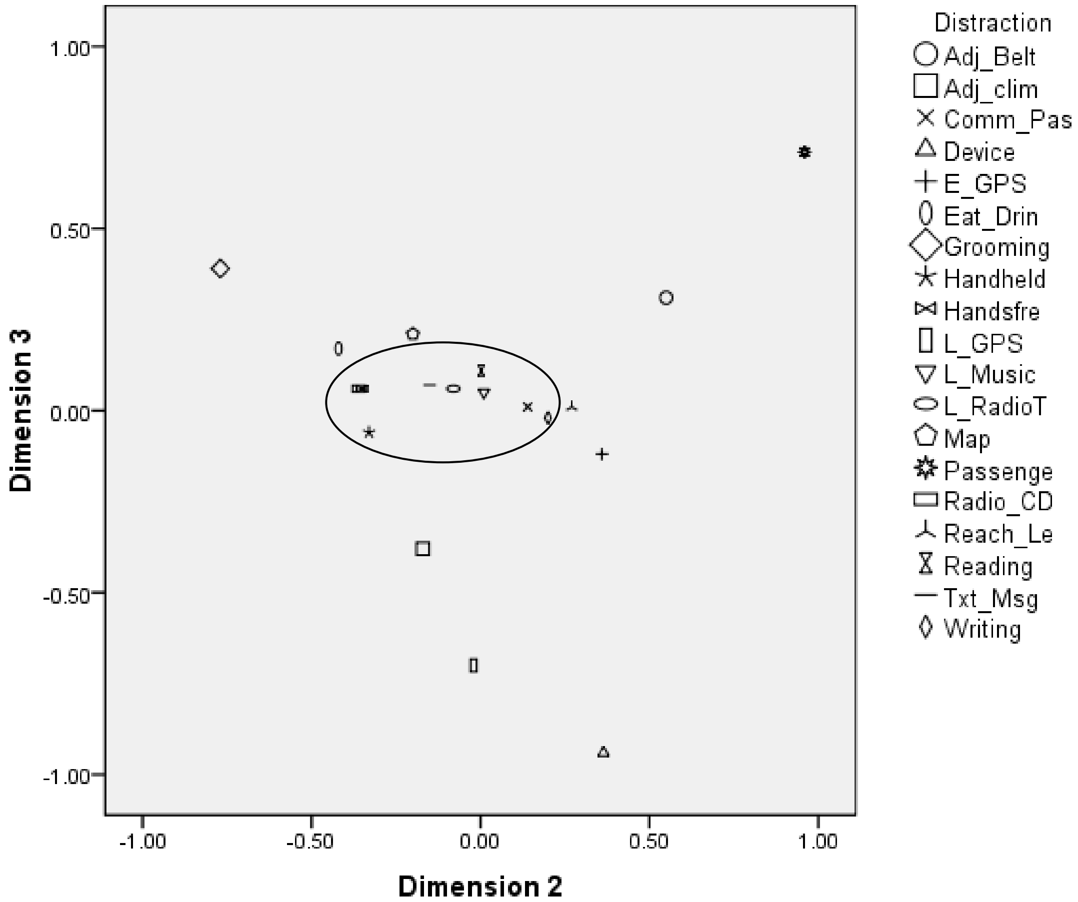


Figure 2: perceptions of risk for each driver distraction represented on dimension 2 & dimension 3

To attribute meaning to the identified dimensions from the multidimensional scaling the location of the distractions on each of the 3 dimensions is correlated with the scores from the measured qualitative characteristics (e.g. control). In line with previous research using this methodology there were inter-correlations between the mean scores obtained from the qualitative characteristic measures (familiarity, knowledge, voluntary or imposed, exposure, probability of a crash, mental concentration, and control). This suggests that the results could be explained using a reduced number of qualitative characteristics. Therefore, a principal components analysis (PCA) using varimax rotation was used identifying two components that accounted for a cumulative total of 84% of the variance. Factor 1 (55%) was comprised of the qualitative characteristics exposure (negative), probability of a crash, and mental concentration. Factor 1 could be seen as a factor representing issues related to the driver's familiarity with the distraction and will be referred to as *factor 1: familiarity* from this point. Factor 2 (29%) was comprised of knowledge about the distraction and the voluntary or imposed nature of the distraction (negative) and will be referred to as *factor 2: knowledge*.

The final step is to correlate the PCA factor scores for each distraction (using the Anderson Rubin regression scores) with the distraction locations on each of the 3 dimensions. Dimension 1 was highly correlated with *factor 1: familiarity* ($r^2$ = .88, $p$ <.001) and dimension 2 was negatively correlated with *factor 2: knowledge* ($r^2$ = -.59, $p$ = .007). Dimension 3 did not show a relationship to any of the measured qualitative characteristics. In addition to identifying measured characteristics that might contribute to the perceptions of risk associated with the distractions visual inspection of the spatial representation can be used [24]. The way that the distractions are grouped or clustered in the spatial representation can suggest other important features in risk perceptions that were not directly measured. Such an inspection reveals a clear central cluster on dimension 3 (Figure 2) which could be suggested to represent distractions that are related to communication (hand held and hands free mobile phone, text messages, listening to a radio talk show, reading, listening to music, communicating with a passenger and writing).

Of additional interest in Figure 1 is the location of hand held and hands free mobile phones (circled) to be almost the same on dimension 2 suggesting an equal level of knowledge for each type of phone use. On dimension 1 the two types of phone are far apart suggesting that respondents believe that using a hands free mobile phone requires less mental concentration and carries a lower probability of a crash than using a hand held phone. This is supported by the disparity between the risk ratings for the two types of phone hands free ($M$ = 4.74) vs. hand held ($M$ = 8.26).

## Discussion

Analyses on the 19 in-vehicle distractions identified which were perceived as risky by the respondents and identified a similar pattern of perceived risk to previous work [25] conducted in the UK as well as extending previous work by expanding the number of in-vehicle distractions. In addition, the analyses have identified qualitative characteristics such as exposure and knowledge as important to risk perception judgements. The techniques employed also suggest elements, inherent in the nature of the distraction that may further contribute to the formation of respondents' risk perception judgements, for example, whether a distraction is linked to communication.

The mean ratings for risk and exposure are important because they suggest the general perceptions that respondents have about the distractions presented. Looking at the relationship between risk and exposure, a strong negative correlation was found suggesting that in general, those distractions perceived to be high risk by the respondents (i.e., reading and writing) are distractions that the drivers in the current sample are not exposed to often. The distractions perceived as low risk, such as listening to music are distractions that respondents are frequently exposed to. There may be several reasons for this, for example, drivers may be choosing not to engage in reading and writing while driving or simply find that they do not need to engage in this activity, hence the low exposure score. In addition, some drivers may choose not to use or do not have access to GPS navigation systems, again meaning that their exposure to such systems is relatively limited. Further investigation of exposure looking at both willingness to engage and necessity while driving would be useful.

The visual maps created using MDS and the salient qualitative characteristics can help to demonstrate what is important to a driver when making a risk perception judgement for a distraction. Dimension 1 showed a very strong relationship to *factor 1: familiarity* representing exposure to a risk, the probability of a crash resulting from that distraction and how much mental concentration is required from a driver. Figure 1 illustrates that distractions that drivers are exposed to most frequently (falling on the negative end of dimension 1), such as listening to music and talking to passengers, are considered to require the lowest levels of mental concentration and the lowest probability of a crash resulting from engaging with the distraction. Conversely, distractions that were rated as low exposure (found on the positive end of dimension 1), such as reading and writing were rated as highly probable to result in a crash and require a great deal of mental concentration from the driver. These ratings are intuitive because one would expect those distractions requiring the most concentration to be the most likely to result in a crash.

Dimension 2 showed a negative relationship with *factor 2: knowledge* from the PCA representing the amount of personal knowledge respondents felt they had about each distraction and how voluntary or imposed the interaction with a distraction. Respondents typically felt that they had a good knowledge for distractions such as mobile phone use, map reading, and eating and drinking while driving. In contrast they reported having much poorer knowledge about distractions such as adjusting a seatbelt, passenger entertainment devices, and using devices such as palm pilots brought in from outside the vehicle (Figure 1). Further research to understand whether the knowledge that the respondents have is in line with existing research would be a useful next step. Knowledge that is, for example, contrary to fact would be an area of primary importance for educational resources.

The interesting location of the two types of mobile phone in Figure 1 suggests one area where driver knowledge may indeed be misaligned to research evidence. Respondents typically responded in a way that indicated their belief that hands free mobile phone use is safer than hand held (dimension 1) while respondents reported an equal amount of knowledge (dimension 2) for each phone type. However, this perception contrasts with a large body of experimental research showing evidence for performance decrements, the most consistent of these being slower reaction times to stimuli while talking on either mobile or hands free phones [26, 27]. Nonetheless, the respondents' ratings were consistent with existing research that illustrates a public misconception that hands free mobile phones are safer to use than hand held [18]. Perhaps this indicates that the heavy media coverage of the law requiring drivers to use hands free equipment may have led drivers to infer that hands free must therefore be safer. Perhaps this is an area worthy of further study and educational focus.

Dimension 3 showed no relationship to the measured qualitative characteristics and it was not immediately apparent what this dimension might represent. However, when dimension 2 and 3 are represented together (Figure 2) 9 of the 19 risks show a cluster that share a similar location on D3. Looking at the nature of these risks they are all distractions that are related to communication. This suggests that this element of the distraction is salient in the female drivers perceptions of risk. This cluster is also quite tightly located on D2 suggesting that the drivers felt they had average to good knowledge about distractions relevant to communication and that they felt that typically such distractions leaned towards being behaviours that were entered into voluntarily.

Communication more broadly also appears to be an important aspect of judgements about driver distractions. For example, in Figure 2 there is a cluster of distractions that look to be related to communication, comprising; reading, writing, texting, listening to a talk show, listening to music, and communicating with a passenger. Communication and comprehension based tasks have been shown to negatively impact driving performance in several studies including those investigating phone use [28], passenger communication [1] and GPS systems [29]. Research has found that listening and responding to verbal messages may reduce the capacity of drivers to adequately process all the important information necessary for safe decision-making while driving [30]. It is noteworthy that respondents' judgements have highlighted a close grouping for communication suggesting its important contribution to the formation of risk perception judgements.

Some of the unexplained variance from the MDS representation of the distractions could be explained by looking at the nature of the task; either visual or auditory. Figure 2 illustrates a possible relationship between the nature of the task and *factor 1: familiarity*, concerned with the likelihood of a crash and level of concentration required. Two clear clusters are apparent, the first, comprised of auditory or comprehension based tasks such as, listening to GPS, listening to radio talk shows, listening to music, communication with a passenger, and hands free mobile use. At the other end of dimension 1 are tasks that could be considered more visual in nature including entering information into a GPS unit, using a hand held mobile phone, reaching for an object, texting, map reading, writing, and reading. This pattern of results is consistent with theories of dual or multiple task performance (see Wickens [31, 32] for a discussion). A detailed discussion of such theories is beyond the scope of the current paper. However, the ratings provided by the current sample do suggest an awareness that there is limited capacity to process, for example, visual information and that visual based tasks (e.g., manipulation of in-vehicle controls) may be perceived as requiring more mental concentration because they require the use of the same resources as driving itself, a task with a strong visual component.

What may contribute to some ambiguity in the results is a lack of clarity between the proactive and reactive use of items such as mobile phones. For example, risk perception might be different if measuring reactive use such as reading a text or answering a call rather than proactive use where the driver writes and sends a text or chooses to initiate a call. The control element is likely to change under such circumstances and might influence the associated perception of risk when a call is made. Drivers are not necessarily passive recipients of the distractions around them in the driving environment and they can choose whether or not to engage in a large number of distractions such as answering the phone. However, research has shown that drivers do not necessarily show a tendency to strategically postpone tasks when they drive [33] and other factors such as driver states (e.g. fatigue) are also thought to impact drivers' willingness to engage in distracting activities [34]. Therefore, a common distraction like tuning a radio is an example of a distraction that respondents are choosing to be involved with while driving, hence the high exposure rating given by respondents. Further investigations would help to clarify the proactive or reactive nature of exposure levels for in-vehicle distraction.

In summary, the female respondents in the current study were making use of information associated with exposure, perceived probability of a crash, mental concentration including the auditory or visual nature of the task, general knowledge and the nature of the task, (e.g., communication based) to form their risk perception judgements for the 19 in-vehicle distractions. Some variance remains unexplained and this could in part be accounted for by concepts that were not measured in the current work as well as being a result of the proactive or reactive way in which drivers might interact with a distraction. Nonetheless the results do suggest features either measured or inherent in the distractions that the female drivers in the current sample used in their risk perceptions. Therefore, concentrating efforts aimed at improving accurate driver knowledge about engaging with in-vehicle distractions should be focussed on features of the distractions that are highlighted as salient to the driver.

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